§33. Application of Advanced High Temperature Superconductors for Fusion Plasma Experimental Devices

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Recent progress on a YBCO tape is quite promising, and a tape with a 212.6 m x 245 A has been developed in ISTEC. In comparison with the BSCCO tape, a YBCO has great advantages; e.g., the current density is much higher than BSCCO, and higher magnetic field larger than 20 T might be feasible. Taking these advantages into account, a tokamak fusion reactor design with a YBCO coil has been carried out.

We are considering to apply this YBCO tape for the internal coil device. Since fabrication and operation of the YBCO coil seems to be premature, we have started from the feasibility study with the miniature floating coil device FB-RT, where a small-sized coil is levitated with a feedback control. Here we have prepared two different YBCO tapes, and characteristics of these tapes are listed in Table 1.

Table 1. Specifications of YBCO tapes.

ISTEC/SRL Nagoya	Critical current	~ 210 A and ~ 88 A
	Width	10 mm
	Thickness	0.12 mm
	Length	10 m
AMSC	Critical current	70 A
	Width	4.35 mm
	Thickness	0.20 mm
	Length	10 m

We tried to wind these tapes for FB-RT coil, a diameter of which is around 90 mm. Winding fabrication was easy for an AMSC tape, while an ISTEC/SRL tape was not so easy due to the stiffness of the tape. Here we have fabricated a coil for the FB-RT with the AMSC tape. A photo of this coil is shown in Fig. 1.

Fig. 1. A photo of FB-RT coil made of a YBCO tape.

Coil parameters are listed in Table 2. The coil is cooled with a field cooling method by using liquid nitrogen, and the coil current is inductively excited. Figure 2 shows the temporal evolution of the coil current for the persistent current mode. The decay constant is estimated to be 2.3 hours.

Table 2. Specification of a YBCO coil for the FB-RT

Inner and Outer diameters	90.8mm/98.4mm
Total turns	30turns
Winding method	Double pancake
Total length	10m
Total weight	123.5g

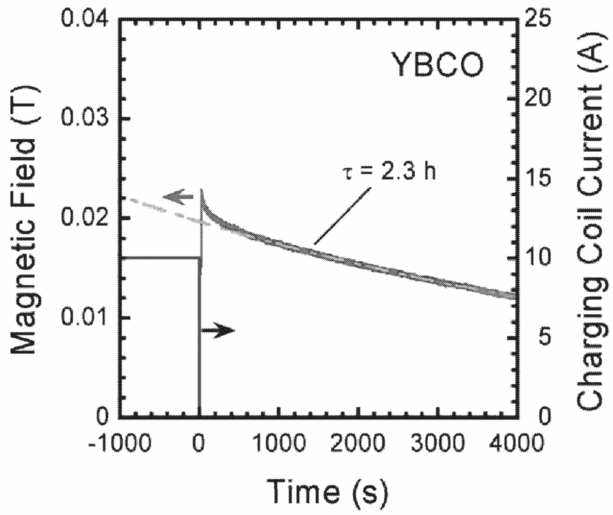

Fig. 2. A current decay of the YBCO coil at the persistent current mode.

Next we have considered the application of a HTS coil for LHD device. In LHD correction coil system called LID is equipped, where a magnetic field of LHD plasma is controlled; e.g., a large m/n=1/1 magnetic island is produced for the plasma experiment. These LID coils are made of water-cooled copper conductors, and located outside the cryostat. We have examined that these copper coils could be replaced with HTS coils installed inside the cryostat. Table 3 shows the comparison between two coil systems.

Table 3 Comparison between copper and HTS coil systems for the LID coil.

	Copper coil	HTS coil
Coil size	2.3 m × 1.9 m	~ϕ0.8 m
Coil turns	48	2000
Coil current	1920 A	200 A
Magnetomotive force	92 kA	400 kA
Power supply	~ 2 MW	< 10 kW

Since the correction coils are located near by the plasma surface in the case of the HTS coil system, the flexibility for the magnetic field configuration is quite superior. In addition, if the PCS switch is employed for the HTS coil, the passive control of the plasma could be available.